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MINIMALISM AS A CONCEPT FOR TEXTILE FINISHING AND FASHION DESIGN

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ABSTRACT

In textile and fashion industry, novel approaches is demanded to create an interactive relation between them. One of these approaches is applying environmental friendly finishing as well as using this concept in fashion design which a type of bio-mimic or environmental simulation. Minimalism concept has been a growing trend in different fields such as design, art, and fashion, which expresses consumer's needs for effortless functionality that can be compatible with a complex modern lifestyle by using limited materials to create a desired effect. In present research woven and knitted cotton fabrics were biofinished using cellulase enzyme followed by stain release treatment. Further, the effect of biofinishing treatment on some physico-mechanical properties of used cotton fabrics; which have a direct affect on UV-blocking ability; namely fabric width, weight, stiffness, and thickness were evaluated and showed significant enhancement. Additionally, UPF of grey and biofinished fabrics were calculated and showed improvement of their values after enzymatic treatment. Finishing using polysiloxane derivative was achieved and to enhance stain release properties, and showed enhancement in their grade values. As well as, the finished cotton fabrics were applied for producing fashionable designs that inspired from minimalism features, which introduced multiple visual and benefit functional properties.

KEYWORDS: Textile Finishing, Biofinishing, UV Protection, Soil Release, Fashion Design, Minimalism

INTRODUCTION

Nowadays, the necessity of functional finishes has been increasing rapidly in textile market because of competition, achieving added values and increasing market share. The consumer's demands and desires are not only defined by aesthetic properties, but also by its functional ones, which could be achieved by applying novel ideas in textile finishing and apparel production.

Enzymes are proteins that consist of long chains of amino acid, held together by peptide bonds. They are present in all living cells and have found wide applications in different fields such as textile industry which applied for improving production methods and fabric finishing due to their positive environmental and commercial impact (Shah 2013). The advantages of enzymes applications for cellulosic fabrics finishing are listed as follows; cleaner fabric surface with less fuzz, process simplification, reduced tendency to pill formation, cost reduction, environmentally friendly process, and improved handling properties of fabrics (Chinta *et al*, 2012; Shah 2013). Cellulase enzymes are nontoxic and environmental friendly biocatalysts that are primarily used to biopolishing process. Biopolishing also called biofinishing is applied to the fabrics to remove the pills and fuzz from fabric surface, in order to improve the smoothness, drape,

flexibility and appearance properties especially for knitwear (Jabasingh & Nachiyar 2012). Unlike conventional softeners, which tend to be washed out and often result in a greasy feel, the softness-enhancing effects of biofinishing are wash-proof and non-greasy. Biopolishing using cellulase enzyme treatment give a partial hydrolysis of cotton; so the short fiber ends are hydrolyzed, leaving the surface of the fibers free and providing a more even look. But it should be considered that there is also a loss of strength related to the amount of weight reduction (Chinta *et al,* 2012; Shah 2013). The recommendation of textiles as a means of sun protection has previously been underrated, even though suitable clothing offers simple and effective protection against the sun (Das, 2010). Prolonged exposure to ultraviolet radiation (UVR) can result in skin damage such as sunburn, premature skin aging, allergies, and even skin cancer. The deleterious impacts caused by over-exposure to UVR have increased the public awareness of the need to adopt personal UV protective strategies (De *et al,* 2005; Kotb *et al,* 2014). Many textile manufacturers try to enhance the UV protective performance of garments using a chemical approach with the use of dyes, whitening agents and UV absorbers such. Nevertheless, the photodegradation of fabric dyes, optical brightening agents and the potential hazard of these chemicals to the human body lacks investigation (Wong *et al,* 2012). Many researchers have studied various fabric parameters that influence UVR transmission, such as fiber composition, fabric construction, yarn twist, thickness, weight, wetness or moisture content, stretch or extensibility, chemical treatment or additives and coloration. Since, UV-resist property can be incorporated by changing the structure of the constituent fibers, varying the weaving pattern, changing the shades in dyeing, or applying a suitable finishing agent or UV absorbers on the fabric (De *et al,* 2005; Das, 2010). The UV protective ability of fabric depends on the amount of UVR reflected or absorbed by fibrous materials, transmitted through pores between fiber and yarn, and also scattered within the fabric layer. Clothing can only provide limited protection against UVR, in particular for knitwear with a more porous and stretchable structure than the woven garments. Fabric construction is one of the important factors affecting these paths for UVR. The arrangement of yarns and fibers determined by fabric construction can influence the compactness of the structure, together with the open space within the fabric. Knitted fabrics are easily deformed or stretched during wearing due to their elastic characteristics. The fabric layer will become thinner when it is worn next to skin and more spaces that are open will be created for transmitting UVR in the actual end-use. It can be anticipated that the UV protection provided by the chemical approach may not always be effective because of the actual wearing condition of garments. Fabric construction is deemed to present the simplest and cheapest solution to achieve good UV protection without additional finishing processes and has been proposed as one of the most important variables affecting UVR transmission, especially when light pastel colored fabrics were used as UV protective clothing (Wong *et al,* 2012). UV-protecting property can be expressed by ultraviolet protection factor (UPF), which indicates a fabric's sun screening capacity (De *et al,* 2005).

During the last several years, specialty organo-modified silicones have been used in stain release and stain repellency textile finishing. These organo-modified silicone polymers may also contain additional reactive organic groups, such as amines, amides and epoxides, which normally contribute to the softness and/or durability. These materials are generally silicone copolymers that have hydrophilic groups, such as polyalkylene oxide polymers, are arranged in different ways onto the main siloxane backbone (Vazquez, 2004). Silicone is a generic term that refers to a class of manmade polymers based on a framework of alternating silicon and oxygen (siloxane bonds) with organic substituent attached to the silicon, the vast majority of which are polydimethylsiloxanes. Because of their Inorganic – Organic structure and the flexibility of the silicone bonds, silicones have some unique properties including thermal oxidative stability and

hydrophobicity properties. Most recently, modified versions of the above as well as new silicone chemistries are being introduced which offer improved softness coupled with the benefit of influencing the stain repellency and/or stain release properties. Additionally; they can improve the cost of textile operations and ensure a minimum environmental impact (Vazquez, 2004).

In the textile industry, designers use other garments, photographs of garments, art objects and natural phenomena as inspiration for their designs. It is generally recognized that these sources of inspiration help designers to create features of individual designs, such as shape details in tailoring or pattern motifs in knitwear. Minimalism is a concept a loose synonym of simplicity, where the simplest and fewest elements are used to create the maximum effect as well as the subject is reduced to its necessary elements. It is one of the most significant movements of the 20th century and early 21st century that penetrated numerous fields, where. Since, it creates an impression of extreme simplicity by enlisting every element and detail to serve multiple visual and functional purposes through using natural textures, neutral colors, clean and fine finishes. The functional minimalism fashion design is using relatively simple structural and decorative aspects to highlight the functional one, creating an elegant design. The characteristics of the minimal design is achieved by using; ornamentations are quality rather than quantity, structural lines for decoration, basic geometric shapes as outlines, a single shape or a small number of similar shapes for components for design unity, natural and non-fussy bright color combinations, natural patterns and accessories. Additionally, the economic and functional value (VanEenoo, 2011; Park and Yim, 2013).

From a minimal point of view, this work is motivated by the concept of minimalism for textile finishing and apparel design; using a reduction as a positive technique, by using biopolishing treatment of woven and knitted cotton fabrics which imparted functional, i.e. soft handle, UV protective and soil release properties without dyeing. As well as producing pleasing and simple apparel designs that applied and carried out by draping on the dress form.

EXPERMENTAL

Fabrics Material

Two types of desized 100% woven[twill 2/1 (232 g/m^2)] and knitted [Melton (329 g/m^2, Rip (261 g/m^2)] cotton fabrics were purchased from SHATEX, Egypt.

Chemicals

Cellulose® enzyme under the commercial name of Cellumax® AP (preuffred acidic powder), hydrogen peroxide 35% were kindly supplied by "International Industrial Company", Cairo, Egypt, DUREX HS-300N (a modified polysiloxane) was supplied by TEXCHEM Egypt CO., Ltd.,. Other chemicals used were laboratory grade reagents.

Methods

All fabrics were simultaneously pre-scoured/bleached post-biofinished in an industrial scale using liquor to fabric ratio of 1:10.

Scouring and Bleaching

Simultaneous scouring and bleaching was carried out using NaOH 5 g/l, H_2O_2 12 ml/l, at 80 °C for 60 minutes followed by rinsing.

Biofinishing

Biofinishing was conducted at 55 °C for 30 minutes using 1% (o.w.f) cellulose enzyme at pH 4.5-5.5 (adjusted by acetic acid), then the temperature raised to 80 °C for 5 minutes, followed by tumble dry.

Stain Release Treatment

Biofinished fabric samples were padded two dip and nip for 20 min at weight pick up 80 % in a bath containing DUREX HS-300N [polysiloxane derivatives] (30 g/l) adjusted to pH 5. Subsequently drying and curing at 100°C for 30 seconds and 130°C for 2.5 minutes respectively.

MEASUREMENTS

Physico-Mechanical Properties

The effect of biopolishing treatment on some physico-mechanical properties of used cotton fabrics; which have a direct affect on UV-blocking ability; namely fabric width and weight, fabric stiffness (Shirley Stiffness Tester) (HU, 2008), and fabric thickness (ASTM D 1777-96) were evaluated.

Ultraviolet Protection Evaluation

The transmittance % was measured for blank and biopolished fabric samples and the UPF was calculated according to the Australian/Newzeland Standard (AS/NZS – 4366-1996) using UV-Shimadzu 3101-PC-Spectrophotometer, using the following equation.

$$\mathrm{UPF} = \frac{\sum_{290\,\mathrm{nm}}^{400\,\mathrm{nm}} E_\lambda \times S_\lambda \times \Delta\lambda}{\sum_{290\,\mathrm{nm}}^{400\,\mathrm{nm}} E_\lambda \times S_\lambda \times T_\lambda \times \Delta\lambda}$$

Where, Eλ is the relative erythemal spectral effectiveness, Sλ is solar spectral irradiance in W/cm^2/nm, Tλ is the spectral transmittance of the fabric (measured), λ is the wavelength in nm and Δλ is the bandwidth in nm.

Stain Release Test

Stain release performance was assessed using AATCC method 130-2000. All fabrics (blank, biopolished, and treated) were stained with a vegetable oil and rated after one home laundering (AATCC 124/2009). On the other hand, stain

RESULTS AND DISCUSSIONS

Physico-Mechanical Properties

The effect of biofinishing treatment with cellulase enzyme of 100% woven (twill), and knitted (Melton and Rip) on fabric width, weight, thickness, fabric stiffness, as well as the blank ones was evaluated as shown in Figures (1-4). Generally, it was observed that there is an interaction between fabrics structure and biopolishing treatment that affected the studied physico-mechanical properties of the above-mentioned fabrics. There is a fact that there are more spaces, holes, and stretch ability in knitted fabrics structure than in woven fabrics, such factors are responsible for the differences in changing before and after biofinishing treatment.

Effect of Biofinishing Treatment on Fabric Width

It is obvious from Figure (1), that there is a significant decrease in fabric width after biofinishing of cotton fabrics

with cellulase enzyme for all of the investigated fabrics (woven and knitted). The contraction in biofinishing fabric width caused the fabric construction to be tightened, decreasing the fabric opening and holes. This shrinkage may be attributed to yarns swelling with subsequent increase in fiber crimp (Chinta *et al*, 2012; Shah 2013)

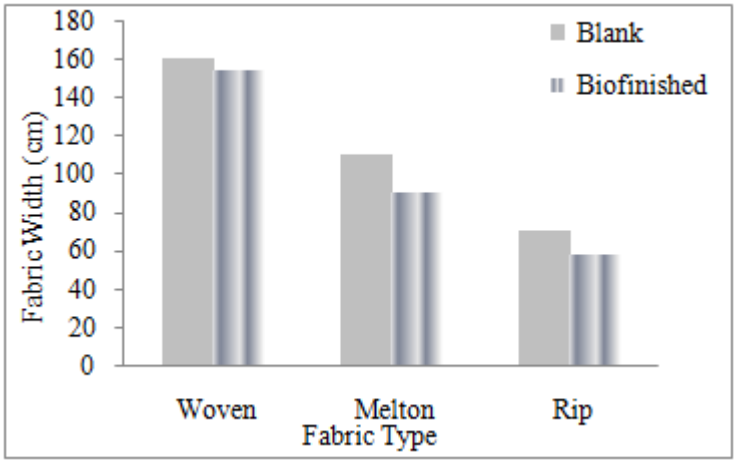

Figure 1: Effect of Biofinishing Treatment on Fabric Width

Effect of Biofinishing Treatment on Fabric Weight

The data in the Figure (2) clearly showed that there is significant decrease in weight values for biofinished treated samples than the blank fabric samples regardless the fabric type. This weight loss may be attributed to the assumption that application of cellulase enzyme on cotton fabrics caused removing of hairy particles. Consequently, results in weight loss where long chain cellulose is converted into short ones. It has been reported that up to 2% weight loss showed the removal of surface fibrils, fragments of seed coat and many other contaminations of the fabric, which gives a smoother, brighter and glossier look (Chinta *et al*, 2012; Noreen *et al*, 2014).

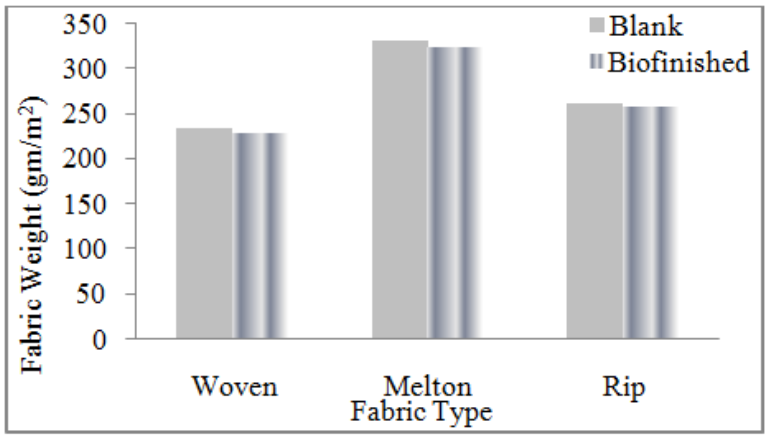

Figure 2: Effect of Biofinishing Treatment on Fabric Weight

Effect of Biofinishing Treatment on Fabric Thickness

The effect of biofinishing treatment on fabrics thickness is represented in Figure (3); the obtained results showed that there is a significant increase in thickness values in comparison to the blank fabrics. The reason for these results is the high amount of mechanical forces and the long process period, which caused fibers swelling and closing the gaps between them.

Hence, along came with removal of the fuzzes from the yarn surface (Chinta *et al*, 2012; Noreen *et al*, 2014).

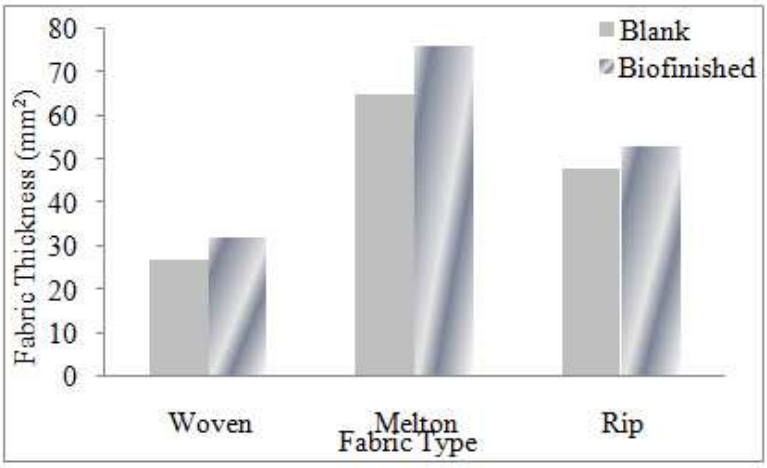

Figure 3: Effect of Biofinishing Treatment on Fabric Thickness

Effect of Biofinishing Treatment on Fabric Stiffness

From the Figure (4), it is clear that although the decrease in fabric stiffness is higher for woven fabric than for knitted fabrics, there is significant enhancement in fabrics stiffness after biofinishing treatment regardless the fabric type than the unfinished fabrics. These results may be attributed to biofinishing treatment with cellulase enzyme give a partial hydrolysis of cotton, so the shorter fiber ends; especially in case of woven fabric because they have more protruded fibers than knitted ones; are hydrolyzed. Subsequently removing the pills and fuzz from the fibers surface and loosing the fibers ends. The improvement in fabrics softness, smoothness, drape, and flexibility are absolute safe, permanent, do not hamper the water permeability and providing a more even look compared to chemical treatments (Chinta *et al*, 2012; Shah 2013).

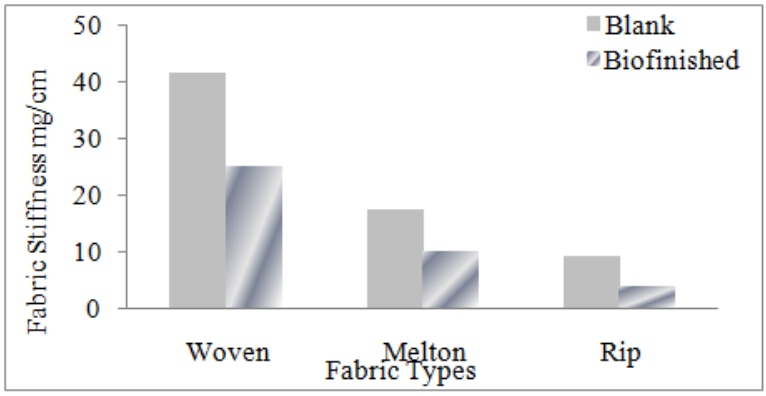

Figure 4: Effect of Biofinishing Treatment on Fabric Stiffness

Ultraviolet Protection Properties

There is a strong relationship between UV transmission and fabric parameters and construction, especially, fabric weave or knit, weight, stretch, opacity, and thickness. The UPF values of blank and biofinishing were calculated according to Australian/Newzeland Standard (AS/NZS – 4366-1996). Although the results showed that the UPF values of all fabric samples either blank or biofinished ones; having excellent protection (50+); the biofinished fabric samples showed higher enhancement in UPF values. There is an interaction between fabric structure, construction, and biofinishing treatment with

cellulase enzyme, since this type of treatment affected on some of fabric physical parameters as proved in previously discussed results. But because of the stretching ability of raw fabric these excellent UPF values susceptible to change due to the repeated wearing forces; especially in case of knitted fabric construction; which make sense and a need for further finishing types for cotton fabrics which improve UPF values (Dubrovski, 2010). The investigated fabric parameters showed that there is a contraction in fabric width, which led to closing the gaps between yarns and increase their compactness, consequently permitting UVR to transmit through the fabric and enhancing their UPF values. As well as the fabrics thickness were increased after biofinishing treatment, decreasing fabrics porosity, producing a closer weave especially in case of knitted fabrics; preventing UVR transmission through the compact fabric surfaces. In most studies, thickness measurements for the fabrics were not undertaken or reported. However, thickness is a useful variable for understanding differences in UV protection between fabrics, i.e. the thicker, denser fabrics transmit less UV radiation and concluded that thickness is most useful in explaining differences in UV transmission (Das, 2010; Wong *et al*, 2012). UV light passes direct through the macrospores or fabric open area (direct UV transmittance) and through the yarns, where changes the direction before leaving the fabric (scattered UV transmittance). Numerous studies focused on different fabric constructional parameters that represent the fabric structure the best and have direct and significant effect on UV protection. Such role has been given to fabric cover factor, fabric open porosity, fabric mass, fabric thickness etc (Dubrovski, 2010).

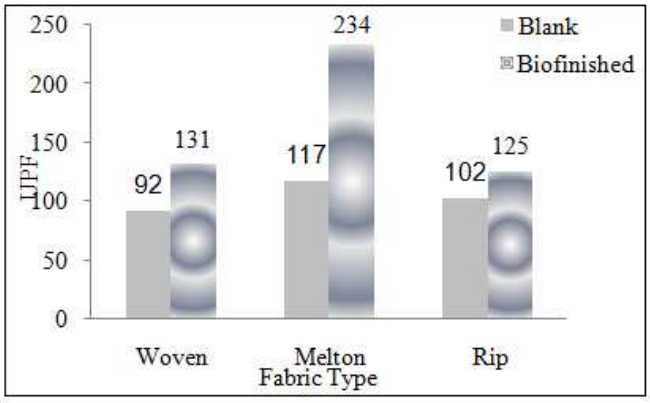

Figure 5: Effect of Biofinishing Treatment on UPF Values

Stain Release Finishing

The stain release properties of gray, biofinished, as well as DUREX HS-300N [polysiloxane derivatives] treated woven and knitted fabrics were evaluated according to AATCC 130-2000 test method. The results in Figure (6) showed that all the gray fabric showed the poorest stain release values regardless the fabric construction. On the other hand, the biofinishing treatment with cellulase enzyme enhanced stain release properties to some extent especially for the woven fabric construction (twill), but still not adequate foe apparel applications if there are no post- dyeing of cotton fabrics. These results may be attributed to action of enzymatic biofinishing treatment with cellulase helped to maintain a clean surface appearance and look, which agreed with enhancement of the previously discussed fabric stiffness results. Cellulase assisted in the removal of particular soils by removing microfibril from the cotton fibers that initially form the pill and build up hardly removed stains (Shah, 2013), which also explained the poorest stain release values of gray fabrics. For the DUREX HS-300N (polysiloxanes derivative) treated fabrics it is obviously showed from Figure (5) that this type of

finishing significantly improved the treated woven (twill) fabric to the best stain removal grade (5), and (4.5) for treated knitted fabrics (Melton, Rip). These results may be attributed to the resinous polysiloxanes action, where three-dimensional crosslinked polysiloxanes will react rapidly with water to form a linear polymer. As long as the aqueous pH is maintained between pH 3-4, stable emulsions can be prepared. When these emulsions are applied to a fabric with a tin catalyst, the Si-H group hydrolyzes to the silanol and condenses to a three-dimensional resinous polymer. Since the negative fiber surface charges attract positively charged particles, making the fabric highly oily stain repellent. Utilizing appropriate monomers and reactive groups, polysiloxanes, better known as silicones, are also found as three dimensional resins and high molecular weight elastomers. Silicones are water clear oils that are stable to heat, light, and do not discolor fabric. They produce a slick silky hand and are preferred for white goods, as well as they improve tear and abrasion resistance and are excellent for improving sewing properties of fabrics (Vazquez, 2004).

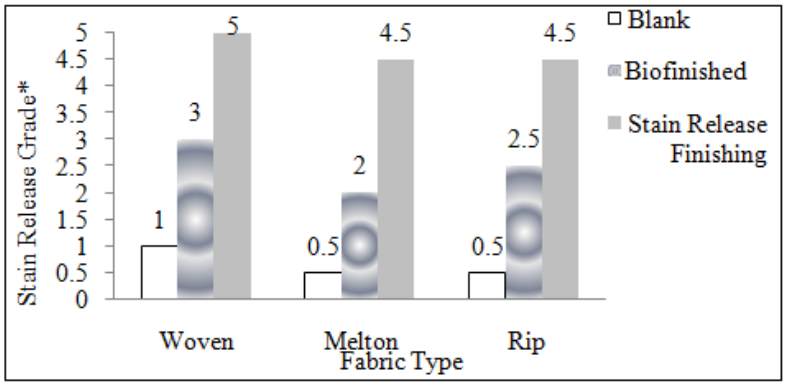

Figure 6: Stain Release Test Results

Where Stain Release Grade 5 represents the best stain removal and Grade 1 the poorest stain removal according to AATCC 130-2000 Method.

APPLICATION OF BIOFINISHED/STAIN RELEASE FABRICS IN MINIMALISM FASHION DESIGNS

Minimalism in apparel design and production could be applied by extreme simplicity by enlisting every element and detail to serve multiple visual and functional purposes through using: (VanEenoo, 2011; Park and Yim, 2013).

- Natural textures, neutral colors, clean and fine finishes,
- Ornamentations are quality rather than quantity,
- Structural lines for decoration,
- Basic geometric shapes as outlines,
- A single shape or a small number of similar shapes for components for design unity,
- Natural and non-fussy bright color combinations,
- Natural patterns and accessories, as well as the economic and functional value.

PROPOSED DESIGNS AND APPLIED DESIGNS

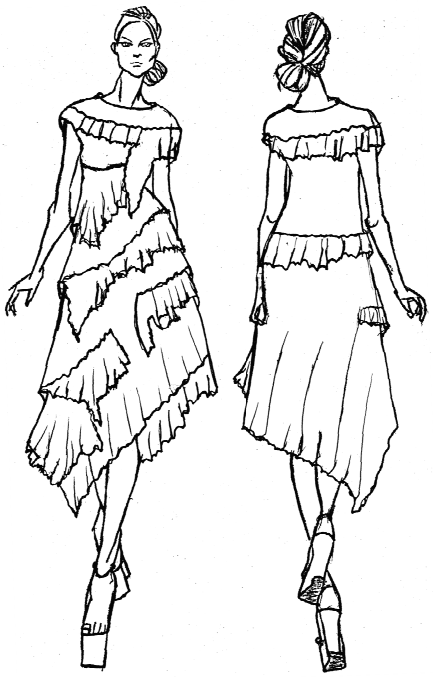

Figure 7: Proposed Design (1)

Figure 8: Applied Design (1)

The design structure

This model consists of one piece - dress; as shown in figure (7); it depends on line and texture in fabric. The main lines used are diagonal which play an important role in moving the eye across side to side and also help to decrease the body width and make the figure taller as well as increasing the activity and excitement. The repetition of ruffles helped to achieve rhythm for model and increases the balance. These ruffles have different textures, because they made from a different material (plain) from the dress (twill).

Minimalism features

This design depends on fabrics ruffles in the same color.

- Using different textures from twill and plain weave to made decorative design by themselves.
- Geometric shapes with broken lines in all design reflect the elements of minimalism features, by precise, hard-edged, geometric forms, and using raw materials color.
- Movement was emphasized in this design by lines diversity, their oblique and also the diversity of its inclination angle.

Fabrics: Woven for dress and ruffles

UPF: 50+ (131)

Stain Release Grade: 5/5

- This design is similar to minimalism in the diversity of elegant lighting, and the void spaces.

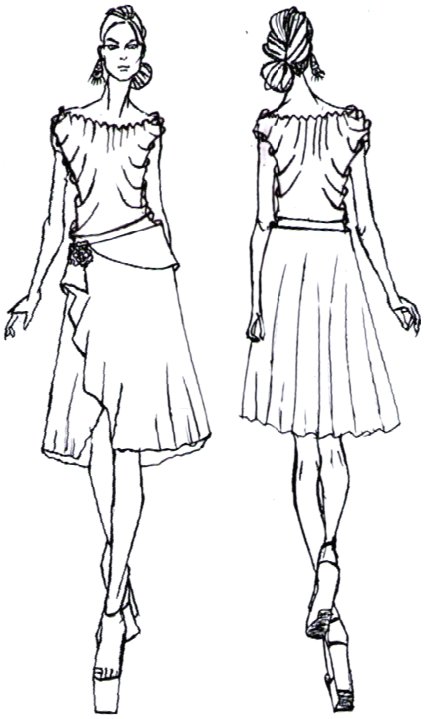

Figure 9: Proposed Design (2)

Figure 10: Applied Design (2)

Fabrics: Rip for blouse and skirt

UPF: 50+ (125)

Stain Release Grade: 4.5/5

The Design Structure

This design consists of two parts; as shown in figure (9); the first is short cover-breast with halter armhole decorates by geometric shapes, a second part is a crossover skirt. Using diagonal lines in upper part making an excitement to the model, and at the same time it helps to increase the attention. The repetition of them helps to connect the two parts of model and make informal balance for the entire design.

Minimalism Features

Achieving simplicity in the whole design, using abstract elements, cold lighting from pleats shadow, and large space with minimum objects.

- Use of plain material emphasize the minimalism art's

properties.

- Extreme simplicity and a deliberate lack of expressive content.
- Pure aestheticism through this use of only diagonal lines around armhole and neck.

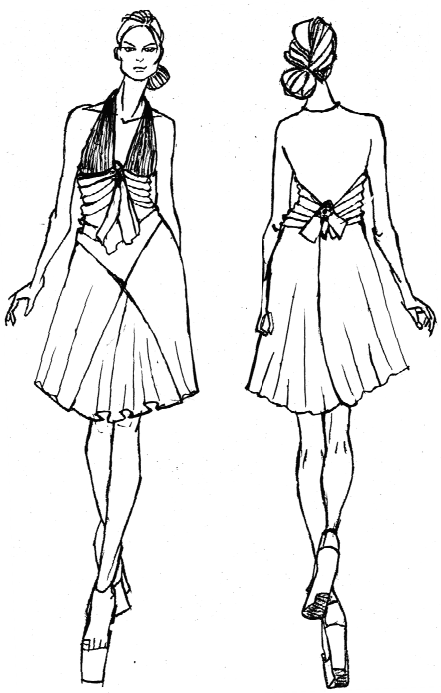

Figure 11: Proposed Design (3)

Figure 12: Applied Design (3)

The design structure

This design consists of two parts; as shown in figure (11); a first part is halter blouse (butterfly style), and a second part is a closed hem skirt. This design emphasizes body curves; it combines dynamic and feminine features. Diagonal lines increased the attention to the model, and connect the different shapes in the design. Textures from face side and reverse side Melton fabric added visual size to burst butterfly blouse, and added more texture in the direction of the left and right skirt.

Minimalism Features

- Conscious of the space in this design achieved decoratively by using texture from face (soft texture) and reverse fabric (shaggy texture).
- Abstracted silhouette emphasis minimalism art.

Fabrics: Melton for blouse and skirt

UPF: 50+ (234)

Stain Release Grade: 4.5/5

- The model textures was carefully arranged to emphasize and reveal an architectural look.
- Using lines in outside sewing, solid color, geometric forms in a closed hem skirt and box like, also in divided model and shaped canvas to achieve minimalism art's properties.
- Decorative by fabric itself with twisting to make butterfly blouse.

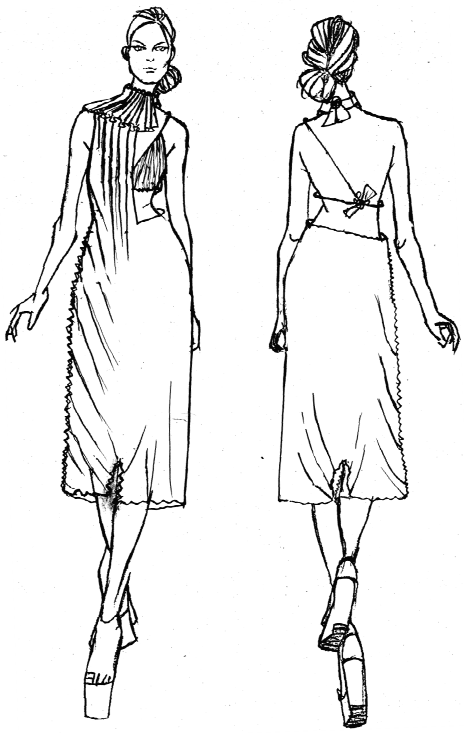

Figure 13: Proposed Design (4)

Figure 14: Applied Design (4)

The Design Structure

The design created from minimalism art by wide gathering and diagonal cutting on breast; as shown in figure (13). Playing by texture in front side fabric (soft texture) and reverse side fabric (shaggy texture). These gathering made pleats in left side which gave free lines of fabrics through using pebbly texture fabric. Making ribbon around the neck and belt in back sewing from side to side provided ease of wearing. Drape in front dress formed and warped fabric at shoulder to make gathering around neck, and the jumpsuit skirt shape with edge finished like trousers. moreover, a cotton T-shirt could be added to all designs in order to increase the UV protective properties.

Fabrics: Melton for jumpsuit and woven for bra cut

UPF: 50+ (234) and (131) respectively

Stain Release Grade: 4.5/5, and 5/5 respectively

Minimalism Features

- Experience all the more strongly the pure qualities of color, form, space and materials without ornamentation.
- Removing complexity of form, and elements of traditional work in order to achieve the concept of pure aestheticism by made button, buttonhole with fabric itself, and create large tie by the same fabric.
- Color was not used in this design which inspired from minimalism art to delineate space.
- Interested how the spectator perceives the relationship between the different parts of the design and of the parts to the whole thing by outside sewing in left side and finished jumpsuit hem.
- The gathers repetition in all design often seen in minimalism art here is designed to highlight the subtle differences in this relationship.

CONCLUSIONS

It was found that enzymatic treatment affected on some Physico/mechanical properties of used woven (twill) and knitted (Melton and Rip) fabrics with differences in changing values, which correspond to fabric construction. It was found that biofinishing treatment with cellulase enzyme approach is used to remove hairy particles, protruded fiber ends, which enhanced the fabric smoothness, UV-blocking, as well as stain release properties. The fabric shrinkage caused by biofinishing treatment by cellulase enzyme led to decrease in UVR transmission through the fabrics, hence producing significant improvement in the UPF of fabrics because of the open area reduction. It could be concluded that adding stain release finishing treatment to the cotton fabrics significantly enhanced the soil release grade, hence the obtained finished fabrics could be used in their gray color state i.e., no need for dyeing and their pollution. The finished cotton fabrics were used for producing four fashionable designs inspired by minimalism movement features, which applied by draping on dress form technique. These applied designs have atheistically and added value properties.

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